all parts of this continent, and our experts are thus enabled to forecast the probabilities by a few hours. Day by day the results are communicated to the public by telegraph in time to avert disaster to the mariners on our eastern coast, and facilitate agricultural operations in the Eastern and Middle States.

Although many of the predictions are still falsified by events, the percentage of fulfilments has become so large as to show that continued research will in the future give us fresh forms of prediction, and increase the usefulness of this branch of science to mankind.

In all departments of geographical knowledge, Americans are at work. They have pushed themselves into the front rank, and they demand the best efforts of their countrymen to encourage and support.

When we embark on the great ocean of discovery, the horizon of the unknown advances with us, and surrounds us wherever we go. The more we know, the greater we find is our ignorance. Because we know so little, we have formed this society for the increase and diffusion of geographical knowledge. Because our subject is so large, we have organized the society into four broad sections, relating to the geography of the land (H. G. Ogden, vice-president), the sea (J. R. Bartlett, vice-president), the air (A. W. Greely, vice-president), the geographical distribution of life (C. H. Merriam, vice-president); to which we have added a fifth, relating to the abstract science of geographic art, including the art of map-making, etc. (A. H. Thompson, vice-president). Our recording and corresponding secretaries are Henry Gannett and George Kennan.

We have been fortunate indeed to secure as vice-presidents and secretaries men learned in each department, and who have been personally identified with the work of research.

WATER-SPOUTS OFF THE ATLANTIC COAST OF THE UNITED STATES.

THE Hydrographic Office has published a very interesting supplement to the Pilot Chart of the North Atlantic Ocean, showing the positions of water-spouts sighted by masters of vessels during January and February in the western portion of the North Atlantic. The map, which is reproduced here, is accompanied by remarks of Everett Hayden, of which we give the following abstract: —

"Although the reports now at hand for these two months were received from incoming vessels only, yet they are very characteristic, and indicate fairly well the regions where these phenomena are of most frequent occurrence.

"Before quoting the reports themselves, it may be well briefly to refer to what is known regarding the character and formation of water-spouts, which are simply special cases of whirlwinds and tornadoes, as these are special cases of cyclones, but on a much smaller scale.

"When a whirlwind is formed over the ocean, water is often drawn up the centre of the whirl some distance, owing to the suction created, and at the same time the moisture in the air is condensed as it rises, so that the name 'water-spout' is very applicable. Indeed, sometimes a spout will burst over a vessel, and flood her decks with water, as a cloud-burst does a mountain-side. When a spout is forming, its upper portion is often visible first, seeming to grow downwards from the clouds. By observing carefully with a telescope, however, it will be seen that the motion in the column itself is upwards, although the moisture in the air which is rising is condensed lower and lower down, thus rendering the whirl visible lower down continually, and making it appear to be actually descending.

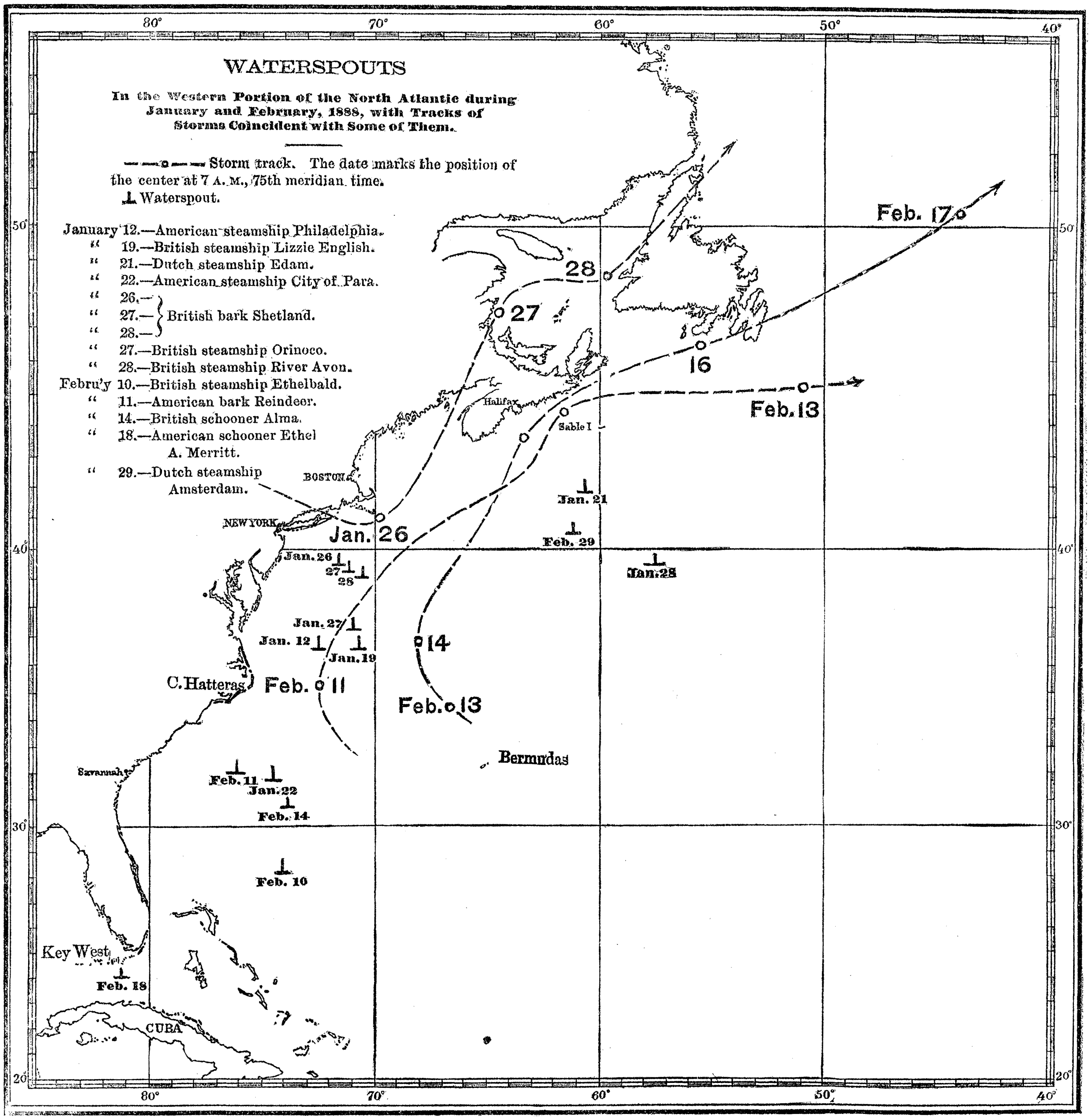
"On Jan. 12, Captain Hess, American steamship 'Philadelphia,' saw four water-spouts in latitude 36° 41′ north, longitude 72° 27′ west. On the 19th, Captain Lawson, British steamship 'Lizzie English,' reports several a little farther to the eastward (latitude 36° 41′ north, longitude 71° 40′ west); and from the Dutch steamship 'Edam,' Captain van der Zee, a detailed report has been received from third officer De Boerk of a large spout sighted at 7 A.M., Jan. 21, latitude 41° 50′ north, longitude 60° 25′ west. In the last case the spout is described as being small and straight at the base, increasing in size towards the top, where it mingled with the clouds. Ascending currents could be plainly seen; there was a strong westerly gale at the time, with occasional hail and snow; temperature of the air 0° C.; water, 11°; direction of rotation of the whirl, with the hands of a watch.

"Another very complete report has been received from Captain Dexter, American steamship 'City of Para,' who saw several large spouts, Jan. 22, in latitude 31° 47′ north, longitude 74° 33′ west. The wind was strong from the north-east, and the sky overcast, with light scud, but the sea was comparatively smooth. Three huge spouts were seen at once, and six in the course of half an hour. The water seemed to be drawn up from the sea, mounting in spiral columns of tremendous thickness, with a loud, roaring sound. Some of the columns were vertical, some inclined at a considerable angle; all of them increased in size at the top, and blended with the clouds. A fine rain or mist filled the air, and continued for some time. The wind soon after changed to east.

"Perhaps the most interesting cases of all, however, are those which were reported Jan. 26, 27, and 28, for the reason that they were clearly associated with a low-barometer area of considerable energy, which moved across the Great Lakes on the 25th, and was central off Nantucket on the 26th. It has been clearly shown by the United States Signal Service, that, when tornadoes occur on land, they take place almost invariably in the southern quadrants of an area of low barometer. It might therefore be expected that whirlwinds and water-spouts would sometimes be found associated in a similar way with a cyclonic storm at sea. The following reports seem to leave no doubt that such is the case. The area of low barometer, which was central over the Great Lakes Jan. 25, barometer 29.7, gathered increased energy when it reached the Atlantic, and off Nantucket the following day the barometer read 29.2; and in the Gulf of Newfoundland, on the 27th and 28th, it read as low as 28.6. The cold, dry, north-westerly winds in the western quadrants of this cyclone, and the warm, moist air flowing into the eastern quadrants, mingled to the southward of the storm-centre, and gave rise to the conditions most favorable to the development of tornadoes on land and water-spouts at sea. Accordingly, Captain Haskell, British bark 'Shetland,' reports that on the 26th, in latitude 39° 34′ north, longitude 71° 16′ west (a little to the southward of the storm-centre), he saw a large spout; the following day (latitude 39° 12′ north, longitude 70° 44′ west) he saw several more; and on the 28th, still more. Captain Garvin, British steamship 'Orinoco,' reports that on the 27th, when entering the Gulf Stream from the north, in about latitude 37° 20′ north, longitude 70° 40′ west, the sea was covered with thick vapor from five to fifteen feet high. The heavy, low-lying clouds seemed to draw the vapor up, and many water-spouts were formed, both large and small; temperature of the water, 60° F.; air, 40°. Captain Cleary, British steamship 'River Avon,' states that on the 28th, in latitude 39° 30′ north, longitude 57° 20′ west, he saw what he took to be a heavy squall to the south-east. Upon looking at it with his glass, he saw that it was a whirlwind, raising the water to a great height. It must have been over a mile in diameter, but he hesitates to even estimate the height to which the water was raised, or the size of the spout, although it must have had terrific power. Shortly afterwards a smaller one passed close to the ship, whirling along the water, and raising the spray to a height of fully a hundred feet. Even as far south as Bermuda the conditions were the same, for on the 27th a whirlwind swept across the parishes of Southampton and Warwick, unroofing houses, blowing down trees, and damaging property generally.

"Similarly, two cyclonic storms, which seem to have originated about the Bermudas on the 10th and 12th of February, as indicated in the weather review published on the March Pilot Chart, were attended by water-spouts, at least one of which was disastrous to shipping. Feb. 10, at 9 A.M., Captain Smith, British steamship 'Ethelbald,' in latitude 28° 18′ north, longitude 74° 06′ west, reports a large spout travelling in a north-easterly direction, rotating, apparently, with the hands of a watch. The barometer was rising; fresh, variable winds, mostly southerly, and sky overcast, with very heavy rain. At this time the American bark 'Reindeer,' Captain Strandt, was about two hundred miles to the westward of the 'Ethelbald,' running up the coast towards New York, in the Gulf Stream. On the 11th the weather became squally, with light southerly winds; and at 10.30 A.M., in latitude 32° 04′ north, longitude 76° 06′ west, when the vessel was under full sail, a heavy

water-spout passed over her, completely dismasting her below the heads of the three lower masts. No previous warning was received; the weather was apparently clear at the time; and the whole affair was over in a few minutes. The dismasted vessel reached Bermuda on the 16th. Again, when the second of these two cyclonic storms was central about latitude 39° north, longitude 67° west, Captain Hogan, British schooner 'Alma,' passed within two miles of a large spout which was travelling from west to east. This was very unsettled weather; wind mostly from the south-westward, but often falling calm and flying to the opposite point of the compass, where it soon died out; thunder and very vivid lightning all around the horizon, but most marked to the north-west and north-east. On the 13th (34° north, 75° west), calm and light variable airs, followed by a breeze from north-north-east, which by midnight increased to a whole gale. Similarly, Captain Paine, American barkentine 'Henry Warner,' reports that during Jan. 21, 22,



at 2 P.M., Feb. 14, latitude 30° 40′ north, longitude 73° 50′ west, and it was blowing a gale from north-north-west at the time. The meteorological conditions prevalent about this time between the Bermudas and the Atlantic coast of the United States are well illustrated by a report made by Mr. Lund, British steamship 'Rothiemay,' Captain Olsen. This vessel arrived at Philadelphia Feb. 20, from Montevideo. From Feb. 1 (latitude 19° north, longitude 58° west) to 9 (27° north, 73° west), fine, pleasant weather, with occasional showers; light to fresh breezes from south-eastward. From the 9th to the 14th (34° north, 74° west), rainy and and 23, off the coast of New Jersey, he encountered light airs going around the compass two or three times every twenty-four hours, exhibiting this same tendency towards the formation of incipient whirlwinds and water-spouts, indicative oftentimes of the gradual generation of a great cyclonic storm.

"A still later report, and one of the best and most detailed which has recently been received, relates to a spout sighted by Captain Battle, American schooner 'Ethel A. Merritt.' This was on Feb. 18, latitude 24° 02′ north, longitude 81° 14′ west, in the Gulf Stream, off Key West, about midway between the Florida Keys

and the coast of Cuba, — only a week after the 'Reindeer' had been dismasted about five hundred miles to the north-eastward. There was a light breeze from the north-east at the time, and the sky was about half covered with nimbus clouds, moving slowly. Just after a light squall had passed by, the first appearance of a water-spout was indicated by the formation of a whirlwind, gradually increasing in size. It was cylindrical in shape below, spreading out above, and rotating in a direction with the hands of a watch. When within about a hundred yards of the vessel, its angular altitude was about 35°, which would indicate a height of only two hundred and fifty feet or less. It was moving to the south-west at the rate of about eight miles an hour. At the base it was transparent; and descending currents seemed to be plainly visible, causing the water at the surface to fly in all directions. A heavy shower of rain accompanied the spout, and the phenomena lasted, in all, about ten minutes.

"Although the study of such reports has already greatly increased our knowledge of the origin and nature of these interesting and often destructive phenomena, much yet remains to be done before we can hope to be able fully to understand the laws by which they are governed. That portion of the North Atlantic from the northern coast of Cuba to the 40th parallel, and from the Atlantic coast of the United States to the Bermudas, is pre-eminently a region where water-spouts are liable to occur, owing largely to the warm, moist air which hangs over the Gulf Stream, and the cool, dry air brought over it by the north-westerly winds from off the coast.

"Among desirable observations to be made, referring to water-spouts, special attention is called to the temperature of the air and water, the reading of the barometer, direction and force of the wind, and the changes which take place in each while the spout lasts; also the direction of rotation of the whirl, and an estimate of its size, character, and changes of form, with, if possible, sketches, however rough, of its appearance at the various stages of its formation and progress."

SCIENTIFIC NEWS IN WASHINGTON.

The Flow of Solids: Solids are not liquefied by Pressure. — The Law of Probabilities: a Discussion of the Doctrine of Philosophical Necessity. — Dynamite Shells: the Progress made by the Ordnance Department of the Army with Experiments with Nitro-Glycerine.

The Flow of Solids.

Mr. WILLIAM HALLOCK of the United States Geological Survey, whose paper upon a new method of making alloys was presented to the Philosophical Society a few weeks ago, read another address upon a somewhat related subject at the meeting of the same body March 17. The question whether solids, he said in substance, possessed any of the properties of liquids, or what conditions will impart such properties to them, is one of ever-increasing importance, to the student alike of molecular physics in general, or of the earth's crust in particular.

The temperature rises as we penetrate the earth: hence, if no other influence affect the substances, the earth has a liquid centre with a thin solid crust. Astronomical and mechanical facts seem to demand a considerable rigidity. Thomson has even demanded a rigidity equal to that of glass or steel. Geological phenomena require a considerable liquid-like motion. With rising temperature, as we penetrate the earth's crust, we also have rising pressure, which probably increases the rigidity of the materials. Cannot we satisfy the demands of both geology and astronomy, and also of mechanics?

In the glaciers we have the grandest examples of the flow of solids. Henri Tresca proved that lead and some other substances would flow, and follow the laws of flowing liquids. W. Spring has extended the list. Monsson actually liquefied ice by pressure. These observations have led many to advocate the idea of a liquefaction by pressure. Others having in view the results of Bunsen, Hopkins, Amazat, and others, maintain that the melting-point is raised by pressure.

Solids can be made to flow: hence that property cannot be used to distinguish solids from liquids. The essential difference between a solid and a liquid is that the relative ease of re-arrangement of the molecules in liquids is very easy, in solids very difficult. Rigidity may be briefly defined as the difficulty of re-arranging the molecules of the body in question. Can rigidity be reduced by pressure? *A priori*, it seems scarcely likely that forcing the molecules nearer together can give them greater freedom of motion. Generally rigidity is inversely as the intermolecular distances. Ice is abnormal, and cannot be taken as evidence *pro* or *con*. Lead, copper, iron, steel, are all hardened by compression. All metals are harder, more rigid, in the drawn, rolled, or hammered state than cast or annealed. The rigidity of a steel pin was raised from 95,000 to 110,000 pounds per square inch by pressure.

Two experiments were described bearing directly upon the question, and are convincing, although they gave unwelcome results to those who made them. The first was conducted under the direction of the Ordnance Department, and is given in full in the report on 'Tests of Metals, etc., for 1884,' pp. 252–285. A mixture of four parts wax and one part tallow was used as a 'straining liquid' in 'tangential' test. It was demonstrated that that mixture would not transmit pressure through a hole $\frac{3}{16}$ of an inch in diameter and $2\frac{1}{2}$ inches long, when the pressure at one end was 100,000 pounds per square inch, and at the other 30,000 pounds per square inch, or less; whereas 2,000 pounds was sufficient to overcome all friction, and force it through, when there was no back pressure: that is, the wax and tallow were rigid enough, under pressure, to maintain a difference of 70,000 pounds per square inch (100,000—30,000) at the two ends of that hole.

The second experiment was also made with the testing-machine of the Ordnance Department at Watertown, Mass. (see *American Journal of Science*, iii. 34, 1887, p. 280). In that experiment silver coins on top of paraffine and beeswax in the holder, instead of sinking through a liquid under 6,000 atmospheres, were pressed so hard against the top of the holder that their impression in the steel was easily seen and felt. The paraffine and wax were rigid enough to impress silver into steel.

Such facts lead us to believe that pressure increases rigidity; and, when we remember that the pressure at the centre of the earth is millions of atmospheres, a demand for the rigidity of steel seems trifling. What is the rigidity of steel? Simply a rigidity capable of resisting 30,000 to 100,000 pounds per square inch. But distinguished geologists have made the fatal mistake of using 'the rigidity of steel' and 'absolute rigidity' as synonymous and equivalent terms. Nothing is more misleading.

Upheavals and depressions, and other geological phenomena, are most beautiful examples of viscous flow of solids. The forces causing a glacier to flow are trifling as compared with those generated in the earth's crust by shrinking; and undoubtedly to cause any body to flow, we only need sufficient force and time.

Can pressure impart to solids the ability to change crystallographically, mineralogically, chemically? Prismatic sulphur naturally changes to octahedral, and in many other cases changes take place under ordinary conditions of pressure and temperature. We should scarcely expect pressure pure and simple to cause a re-orientation of the axes of the two crystal fragments, even if it could perfectly weld them together. Nor should we expect pressure, without heat, to impart the ability to complete the fusion of a lump of barium sulphate in sodium carbonate, even after the process had been well started by heat. Under the extremely complex conditions, it is difficult to generalize. A welding-together is not only theoretically but practically possible between two chemically clean surfaces that fit, but any operation which requires an increase of freedom in the molecules would scarcely be assisted by pressure. Cohesion and adhesion I believe to be identical, and molecular rather than molar.

The bearing of these ideas, if good, upon geological phenomena, is somewhat thus: by the action of pressure and time we might find a sandstone, or such material, compacted, and rendered coherent or even continuous, the most plastic constituents yielding most, and the most viscous retaining their shape most perfectly. Some constituents might even appear to have been fused and filled in between the rest. Certain crystallographic changes might take place, but more than the slightest chemical effect of the constituents upon each other is not to be expected. The case becomes infinitely complex, and a subject for conjecture only, if the temperature is high. An indisputable fact in this connection is that